pheric conditions for such work, was only thirteen inches in diameter.

In closing this informal address, I beg to relate an incident which bears upon the question of the success of the excellent and beautifully finished new instruments which we are invited to inspect at the close of this meeting: In the year 1893, a prominent citizen of California, connected at the time with the educational system of the State, visited the Lick Observatory and inspected its instruments. I well recall his expression of disapproval when he saw that the brass tube of the Crocker telescope, with which Professor BARNARD was securing his famous photographs of the Milky Way and comets, looked worn, and did not carry the polish which one sees on the companion-rail of a steamship. And later in the day, when the star spectroscope, which Professor KEELER had used so successfully in measuring the motions of the planetary nebulæ, and in investigations on objects of special interest, was seen to be worn and scratched from five years' continual use, it was remarked, quite forcibly, that we did not seem to be taking very good care of our instruments.

The most comprehensive good wish that I can make for the Berkeley Astronomical Department, in whose success we all rejoice, is, that when the Astronomical Society of the Pacific is again invited to hold a meeting in the Students' Observatory we shall find the varnish worn away from many parts of these new instruments.

HISTORY AND AIMS OF THE STUDENTS' OBSERVATORY.*

BY A. O. LEUSCHNER.

The buildings and equipment which we dedicate to-night bring us considerably nearer to the realization of the hope of having at the University of California a well-equipped Students' Observatory. Our hearts are full of gratitude to those who have helped us meet our most pressing needs.

*Address delivered before the Astronomical Society of the Pacific, January 30, 1904, at the dedication of the new observatory buildings of the University of California. Rewritten for the *Publications* of the Astronomical Society of the Pacific.

On behalf of the Berkeley Astronomical Department, I thank Mr. WILLIAM M. PIERSON for the gift of his splendid eight-inch reflector; Mrs. HERMAN OELRICHS, for the donation of the late Senator FAIR'S five-inch refractor; the President and the Hon. Board of Regents, for the erection of suitable buildings; and last, but not least, again, President WHEELER, who is ever taking a keen interest in all that concerns our students, for causing the regular budget of the Students' Observatory to be increased so as to enable us to make material additions to our equipment. The total value of our new possessions is over nine thousand dollars, the value of the new equipment alone being over five thousand dollars. Our thanks are also due to Professor JOHN GALEN HOWARD, Supervising Architect of the University, and his staff, for the care taken in meeting our requirements, with reference to the design of the new buildings, and to the California School of Mechanical Arts, particularly to Messrs. G. A. MERRILL and E. T. HEWITT, for their aid in the construction of the photographic telescope and the running-gears of the new domes. Dr. A. F. GILLIHAN and Mr. VAL. ARNTZEN are to be particularly complimented for the energy and efficiency displayed by them in the construction of the photographic telescope and in putting our new equipment in place.

The new buildings are intended to be temporary, and are constructed of wood. They consist of a main building, with domes for the Oelrichs and photographic telescopes, and a separate dome for the Pierson reflector. The main building extends north and south on the west slope of the hill on which the Students' Observatory is situated, and faces east. It contains, aside from the domes, two large rooms, 30 x 30 and 20 x 30, on one floor; also a photographic dark-room and store-rooms in the basement. The reflector dome is located on the south slope of the hill.

The new equipment includes the Pierson (Newtonian) reflector, of 8 inches aperture and 6 feet focal length, by BRASHEAR; the Oelrichs refractor, of 5 inches aperture and 6⅓ feet focal length, lens by ALVAN CLARK and mounting by GAERTNER & Co.. Chicago; a mounting designed and constructed in the University for the Harrison portrait-lens, of 5½ inches aperture and 22 inches focal length, a Repsold

measuring-apparatus for measuring positions on photographic plates, and a Gaertner comparator for measuring spectrograms.

In addition to these improvements a wooden platform surrounding three piers has been erected in the open space between the old and new buildings, for use as an open-air observatory with portable instruments. The three instruments in question, which have been loaned to the department, are a 3-inch equatorial of 4 feet focal length, a 1¾-inch Browning transit-instrument, and a 1⅛-inch altazimuth instrument, with circles graduated to 5″.

Our new acquisitions are primarily intended to increase the efficiency of our instruction in practical astronomy, but they will also afford the members of the department considerable opportunity for original observation.

The Students' Observatory of the University of California occupies a unique position among the astronomical observatories in this and other countries. Founded originally for the purpose of giving a few civil-engineering students the astronomical knowledge necessary to their profession, its development ever since has been in the direction of creating new opportunities for the study of astronomy in all its branches, until now it is well recognized that the University of California, with its two astronomical departments—the Lick and the Berkeley—has a well-organized and prominent training-school for the profession of astronomy. It was through the efforts of Professor FRANK SOULÉ, head of the Department of Civil Engineering, ably assisted by Professor WILLIAM THOMAS WELKER, then Superintendent of Public Instruction, that an appropriation of ten thousand dollars for the erection of a Students' Observatory was secured from the Legislature of the year 1885. The appropriation was most wisely and economically expended, about one half being applied to the erection of the necessary building and one half to equipment.

Instruction in this little observatory commenced in the fall of 1887. I well remember the fine impression which the observatory made upon me when I first visited the same in 1889, during my career as a student in the Lick Observatory. Coming down from the great Lick Observatory, with its huge and magnificent instruments and perfect equipment, the Stu-

dents' Observatory impressed me as a neat and complete model of what a large observatory should be.

The observatory building then consisted of the dome, housing the 6-inch equatorial of 8⅓ feet focal length; the small instrument-room for minor apparatus; the transit-room, containing the 3-inch Davidson zenith and transit telescope; the Howard mean-time clock, the chronograph, and the switch-board; and two small rooms. A small house in the rear harbored the Ewing, Gray, and Duplex seismographs. The minor equipment included a spectroscope, sextants, chronometers, level-trier, and spherometer.

Since then the observatory has been enlarged four times, by the addition of a computing-room, 17 x 30; an office for the Director; a lecture-room, seating 200 students; and the buildings which are being dedicated to-night.

In the earlier days the headquarters of the Department of Civil Engineering and Astronomy, of which the Students' Observatory formed the other part, consisted of one room on the top floor of North Hall. The head of the department and one instructor made up the staff. It was not long before the burden of carrying the instruction in civil engineering as well as in astronomy became so great that Professor SOULÉ was forced to ask to be relieved of the latter, and in 1892 the courses in general and practical astronomy, offered for the benefit of the civil-engineering students, were assigned to me while I still retained my connection with the Department of Mathematics.

It was at this time that the tremendous possibilities in the University of California for the development of a successful department of instruction first impressed themselves upon me.

The ideals which since then have constantly been kept in mind were first to shape the undergraduate work in astronomy so that upon graduation the student would be found fully qualified to take part as an assistant in the regular work of a large observatory, and then to develop graduate instruction in such lines as could be satisfactorily undertaken at Berkeley. At the same time the original purpose of the observatory—to afford the necessary instruction in astronomy and geodesy to civil-engineering students—has been carefully adhered to. Provision has also been made for special instruction in navi-

gation and nautical astronomy for students in the College of Commerce. Aside from these functions of the observatory, which provide instruction for students with specific views in mind, the department has organized general lecture and observatory courses, open to all students of the University, for the benefit of those who wish to familiarize themselves with the fundamental principles of astronomical science, their philosophy and historical development. In these courses special attention is paid to modern methods of research and new discoveries. Among others, the course in modern astronomy is given jointly by the Lick and the Berkeley Astronomical Departments and every member of the University enjoys, therefore, the opportunity of being brought into immediate contact with the most recent work of our great Observatory at Mount Hamilton.

That there always has been and now is call for a thorough training-school for the astronomical professions needs hardly to be emphasized. Perhaps no science attracts the popular fancy more than astronomy. As a result many gifted men and women acquire small telescopes and devote themselves as amateurs to a certain limited class of observations, often reaching therein a perfection which places their names prominently before the world. A university should extend to them every opportunity to combine with their enthusiasm, energy, and brilliancy a profound knowledge of the necessary principles of mathematics, physics, and astronomy. Many university graduates who in their undergraduate career plan to become astronomers later find that the institutions which they have attended were not prepared to give them the necessary instruction and guidance.

The necessity of a thorough preparation for the professions of medicine, law, and engineering has long been recognized, and the energies of most universities are bent on offering the best possible preparation for them. Of the pure sciences none is so much in need of similar attention as astronomy, as it depends in an unusual degree upon allied sciences, particularly upon mathematics and physics.

The question, however, might arise whether or not the organization of a department of instruction in astronomy at Berkeley would involve a serious and undesirable duplication

of the work of the great Lick Observatory, which forms an integral part of the University. We might ask ourselves whether a university should abandon its medical instruction because it is in touch with famous hospitals. Would the hospital work be of benefit to any one but a qualified student for further experience? Is such a university not all the more under obligation to organize the best possible medical instruction, so as to give its young doctors the full benefit of the available hospital opportunities? Or would it be feasible to attempt the instruction in the various branches of science upon which medicine depends in the hospital itself? And, further, ought graduate or research work in astronomy be attempted at Berkeley? Is not the work of our new Physiological Laboratory under Professor LOEB of the highest importance to medical science? Is there not research work in astronomy which is similarly related to the observational work of a great observatory? Among others, *theoretical astronomy* and *celestial mechanics* certainly are.

The two directions in which the energies of the department at Berkeley ought to be applied, clearly defined themselves at the outset, and ever since the aim of the department has been to develop elementary and advanced instruction in all branches of astronomy, and to organize, in particular, graduate and research work in theoretical astronomy and celestial mechanics.

Thus our aims have been to supplement rather than duplicate the work of our great Observatory at Mount Hamilton. No astronomical department, however, can be of great service to intending astronomers without the hearty co-operation of other departments, particularly of mathematics and physics. It is only fitting that on this occasion acknowledgment should be made of the hearty co-operation which the heads of these departments in this University have shown at all times in providing for the needs of our astronomical students.

The first important step in the development of our so-called "School of Astronomy" was taken in 1894, when the College of Civil Engineering organized a special undergraduate course in astronomy and geodesy. With the organization of our College of Natural Sciences and the growing demand for instruction in pure astronomy, this course was taken out of the College of Civil Engineering. A few years later the Stu-

dents' Observatory was separated from the Department of Civil Engineering and Astronomy, the new department receiving the name of "Berkeley Astronomical Department."

A new impetus was given to the efficiency of the work of higher instruction in astronomy in 1898, when, at the recommendation of Director KEELER, a vacancy in the regular staff of the Lick Observatory was filled by the appointment of three graduates of the University of California to fellowships in the Lick Observatory, with the privilege of spending one term each year in graduate work at Berkeley.

When I made a suggestion in this direction to Professor KEELER on the day of his arrival in California, he expressed his doubts as to the value in a large observatory of young graduates whose sole experience consisted in the astronomical work done as undergraduates, but he agreed to try the experiment for one year. A few months later, at a meeting of the heads of departments at Berkeley, he expressed regret that more fellowships were not available for our graduates. Since then the Lick and the Berkeley astronomical departments have commenced to vie with each other in meeting the needs of graduate students.

While at first the time of Fellows at Mount Hamilton, by force of circumstances, was much taken up with ordinary routine work, Director CAMPBELL is lending his energies more and more to create for them opportunities and facilities for original research, so that it would seem that at present, through the co-operation of the various departments concerned, the organization of the instruction in astronomy and its allied subjects, particularly for candidates for the degree of Doctor of Philosophy, leaves little to be desired.

The University of California has already turned out a formidable array of young astronomers. Some of its graduates are at the head of astronomical departments in Eastern institutions. The two men who compose the staff of the Mills Expedition of the Lick Observatory to South America were first introduced to the science of astronomy in this building. One man is a research assistant in theoretical work under Professor NEWCOMB in the Carnegie Institution at Washington. Several are rapidly rising in the United States Coast and Geodetic Survey. One is instructor in this depart-

ment, and so on. Eight have been found worthy of appointment to fellowships in the Lick Observatory. In this connection, it may be stated that only students who give evidence of exceptional qualifications as accurate observers and computers, and of ability for original research, are recommended by the Berkeley Astronomical Department for admission to the Lick Observatory.

Many students of astronomy turn their eyes to California for the completion of their training. During the few weeks which have elapsed since the opening of the current semester, this department has received no less than four applications from men and women already actively engaged in astronomical work, with reference to the conditions on which they might continue their theoretical work at Berkeley, and no doubt Director CAMPBELL receives even more applications from advanced students who desire to profit by the unexcelled opportunities of the Lick Observatory.

Thus our efforts seem not to have been in vain. Not long ago, Professor NEWCOMB was reported to have stated that there were two things standing out prominently in astronomical science of to-day: on the one hand the never-ceasing flow of new and startling observational results from the Lick Observatory, and on the other the production of men, well trained for their profession, in the University of California.

It is our constant aim to turn out men who are not merely astronomical practitioners, but *scholars* in the true sense of the word. It is scholars who are needed in astronomy—men capable of promoting science.

An outline of the various courses of instruction offered to astronomical students has been printed by the University under the title "Announcement to Students" by the Lick Astronomical Department and the Berkeley Astronomical Department. It may not, however, be without interest to state here a few characteristic features of the instruction given in this department. First of all, we make it clear to students who desire to prepare for an astronomical profession that their chief reward in later life will consist in the satisfaction which they will derive from their work. Only those who prove themselves to be exceptionally well fitted for astronomical work are encouraged to continue their studies. The quality of

the students enrolled, and not numbers, count in our advanced classes. At all times a close personal contact between students and instructors is preserved, the student sharing whatever problem the instructor may be engaged upon.

In the practical courses we have no set programme of observations and reductions. A student is kept at work from the very beginning with the same instrument—generally the sextant—until he can use it with the skill of an experienced astronomer. This means slow progress at first, but our experience has taught us that the student who thoroughly masters one instrument is not satisfied until he can handle every other instrument equally well. It is in this way that the student will gradually acquire that taste for thoroughness and accuracy so characteristic of BESSEL. With the instrument which he has mastered the student takes part in such work as the observatory undertakes from time to time. Students are not taught to do approximate work first, but the greatest accuracy is aimed at from the outset. Approximate work where it is sufficient can only then be done intelligently, when the subject is first thoroughly mastered. Problems are selected which require the greatest skill. Thus by stellar distances students have determined with great accuracy the eccentricities of our sextants and have determined the longitude by lunar distances. In practice the last-named experiment has become obscure, but its training value cannot be underestimated. By the telegraphic method students have furnished the observatory with accurate determinations of the differences in longitude between Berkeley, Mount Hamilton, and San Francisco. Extended latitude series by TALCOTT'S method are available for discussion; similarly, comets, asteroids, and variable stars are observed from time to time, etc.

In theoretical work the same thoroughness is aimed at. Independent thought is cultivated in students, as well as a critical attitude toward what they receive in lectures or from books. Mechanical reduction of observations without a thorough knowledge of the subject is distinctly discouraged. In the theory of orbits a comparative study is made of the various methods proposed for deriving the elements of newly discovered comets or asteroids, with a view to enable the student to select in a given case the method best suited to the solution of

the orbit on the basis of the underlying conditions. A senior, before graduation, is expected to be ready to calculate at a moment's notice a preliminary orbit and ephemeris of a newly discovered comet or asteroid.

This work has been extensively practiced in the past, and on more than one occasion students of this University were the first to announce the orbit of a new comet. By making the student participate in the real astronomical work of the day, his ambition and enthusiasm are constantly stirred.

The numerical determination of the perturbations of the Watson asteroids supplements the work in the seminary or the lecture-room.

A great part of the scientific output of the Students' Observatory must be considered to consist in the later achievements of the men who go forth from it. Owing to the large amount of time devoted to the training of students the members of the department are naturally handicapped in prosecuting their own researches. It is not uncommon for us to find ourselves called upon to drop our own investigations at a critical point, in order to assist a student in his work. Nevertheless, we have been able to publish some observations and theoretical investigations which are not without value, and several important papers are now awaiting the finishing touches for publication.

This account of the aims and the history of the Students' Observatory would not be complete without touching upon some of the wants still felt. Aside from the new observatory which is to form part of the Greater University under the PHŒBE HEARST plans, this department needs above all the establishment of some scholarships or fellowships.

I trust that the members of the Astronomical Society of the Pacific, whom we so gladly welcome here to-night, and who I hope will be seen frequently in these buildings hereafter, will aid us in our ambitions. Perhaps some day they may wish to make their headquarters on these grounds, thus benefiting themselves and us by closer contact with one another.